Laboratory Instruments Available to Support Space Station Researchers at Marshall Space Flight Center

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Abstract

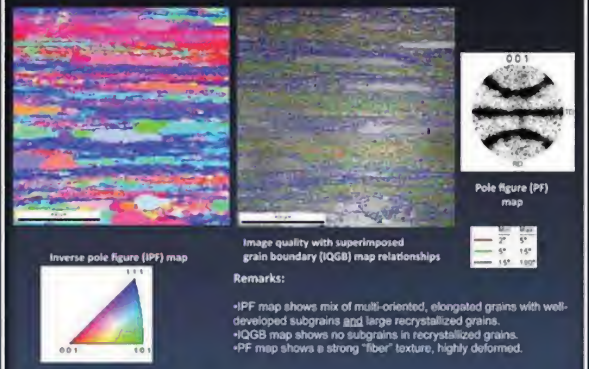
A number of research instruments are available at NASA's Marshall Space Flight Center (MSFC) to support ISS researchers and their investigations. These modern analytical tools yield valuable and sometimes new informative resulting from sample characterization. Instruments include modern scanning electron microscopes equipped with field emission guns providing analytical capabilities that include angstrom-level image resolution of dry, wet and biological samples. These microscopes are also equipped with silicon drift X-ray detectors (SDD) for fast yet precise analytical mapping of phases, as well as electron back-scattered diffraction (EBSD) units to map grain orientations in crystalline alloys. Sample chambers admit large samples, provide variable pressures for wet samples, and quantitative analysis software to determine phase relations.

Advances in solid-state electronics have also facilitated improvemants for surface chemical analysis that are successfully employed to analyze metallic materials and alloys, ceramics, slags, and organic polymers. Another analytical capability at MSFC is a magnetic sector Secondary Ion Mass Spectroscopy (SIMS) that quantitatively determines and maps light elements such as hydrogen, lithium, and boron along with their isotopes, identifies and quantifies very low level impurities even at parts per billion (ppb) levels. Still other methods available at MSFC include X-ray photo-electron spectroscopy (XPS) that can determine oxidation states of elements as well as identify polymers and measure film thicknesses on coated materials, Scanning Auger electron spectroscopy (SAM) which combines surface sensitivity, spatial lateral resolution (~20 nm), and depth profiling capabilities to describe elemental compositions in near surface regions and even the chemical state of analyzed atoms.

Conventional Transmission Electron Microscope (TEM) for observing internal microstructures at very high magnifications and the Electron Probe Micro-analyzer (EPMA) for very precise microanalysis are available as needed by the researcher. Space Station researchers are invited to work with MSFC in analyzing their samples using these techniques.

Field Emission-SEM (FEI Quanta 600): Provides very high resolution and depth of field. It can examine metallic, non-metallic, and wet samples up to 12 inches in diameter. Uses EBSD to evaluate grain orientations. Resolution is 2nm@30KV, magnification range is 7x to 1Mx. in pressure under 20 Torr (maximum), with particle analysis systems and SSD energy dispersive spectrometry (EDS).

EBSD Images for A Partially Recrystallized Aluminum Alloy

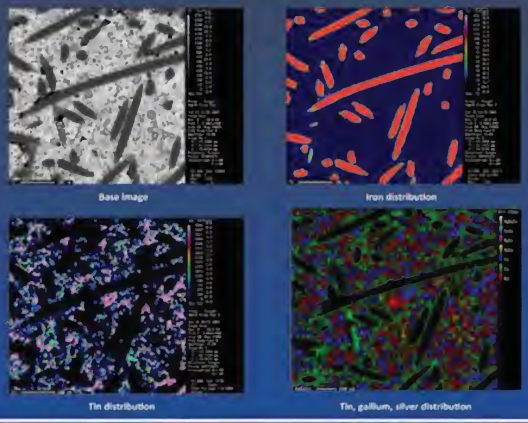


Remarks:

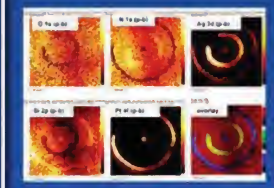
- IPF map shows mix of multi-oriented, elongated grains with well-developed subgrains and large recrystallized grains.
- IQGB map shows no subgrains in recrystallized grains.
- PF map shows a strong "fiber" texture, highly deformed.

JEOL Superprobe(JXA-8900R): Scanning Microprobe allows for precise chemical analysis down to ppm levels using x-rays. Uses four spectrometers with a large chamber size that can accommodate either fractured or flat samples

Microprobe Analysis of An Amalgam Composite

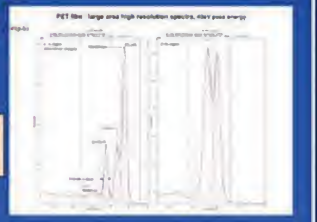


ESCA- Auger System (Kratos AXIS Ultra): Instrument uses both white and monochromatic X- rays for chemical analysis of thin surface films, including depth profiling. Can identify elements and their chemical compositions and oxidation states. Applications include imaging and identification of compounds, films, and polymers.



X-ray parallel imaging on patterned sample.

ESCA Cabilities



High-resolution spectra of poly-ethylene terephalate, with three carbon and two oxygen peaks corresponding to different electronic binding levels in the polymer.

Secondary Ion Mass Spectroscopy (SIMS, Cameca IMS-6f): It uses secondary ions from sample surfaces to identify and quantify elements and their isotopes. It is sensitive to all elements and impurities at ppm levels. Can map locations of all elements including hydrogen, incorporate elemental distribution, depth profile, and quantitative analysis. Requires flat polished samples and very high vacuum.

Perform Qualitative and Quantitative Chemical Analysis of Slag Cross Sections

Identify elemental distributions in slag using scanning electron microscope (SEM) with x-ray mapping.

Identify precise quantitative chemical composition of slag features, using electron microprobe.